NASA Facts

National Aeronautics and Space Administration

KSC Transporters

Transporters of several types are used throughout the Kennedy Space Center's Launch Complex 39 Area to move orbiters, solid rocket motors, payloads and the Space Shuttles. The transporters grew out of a need to move Project Apollo flight hardware and supporting structures, and later, the various elements supporting Space Shuttle launches. The oldest type currently still in use at KSC is the crawler transporter; the newest is the payload canister transporter. Each serves a unique purpose.

Above left: The Payload Canister Transporter delivers the canister to the launch pad.
Top right: The orbiter transporter with Discovery on top, rolls into the Vehicle Assembly Building.
Bottom right: The Solid Rocket Motor (SRM) Transporter with its cargo.

Early Concepts

In 1961, President John F. Kennedy set a national goal of making a manned landing on the Moon before the end of the decade. The National Aeronautics and Space Administration was assigned the responsibility of accomplishing this awesome feat. At the time, neither the huge and extremely sophisticated flight hardware nor the supporting launch facilities existed.

While other NASA facilities tackled the job of designing and developing the Saturn V launch vehicle and the Apollo spacecraft for transporting three men to the Moon, Kennedy Space Center began the design of the launch complex.

Heading the team at KSC was Dr. Kurt H. Debus, Center director and rocketry pioneer with launch experience dating from the 1930s.

Because of the size and complications of handling the huge Saturn V rocket and the adverse environmental factors of wind, rain, highly corrosive salt air, electrical storms and hurricanes that exist at KSC, Dr. Debus's team departed from the conventional methods of assembly and checkout of the launch vehicles at the launch pad. He decided that the Saturn V would be assembled and checked out in a Vehicle Assembly Building (VAB) and then transported to the launch pad on a mobile launch pad and tower.

Conveyance of the mobile launcher and Saturn V to the pad posed no small problem in the 1960s. The rocket and launcher would weigh 12 million pounds, and the distance would be 3.5 miles to Pad A and more than 4 miles to Pad B. In addition, a portable service tower would be required to be transported to the launch pads to service the Saturn V.

Three concepts of transporting the vehicle and launcher were proposed: a barge and canal system, a rail system, and a land transporter. The task of selecting one of the three systems and then transforming a concept into reality fell to D.D. Buchanan, chief of the launcher systems and umbilical tower design section.

Carrying the Apollo 11 Saturn V space vehicle and mobile launcher, the crawler transporter inches its way to the hardstand on Launch Complex 39A, where it will position the 12.5-million-pound load on support pedestals.

After a year of study, the cross-land tracked vehicle, or crawler transporter, was determined in 1962 to be the most feasible conveyance.

Early concepts showed the transporter integral with the mobile launcher, but exposure to launch damage and possible long repair periods influenced the selection of a transporter that would be completely self-powered and separate from the structures.

The transporter would be the largest land vehicle ever constructed, would weigh six million pounds, and would be capable of transporting the mobile launcher with an assembled Saturn V or the mobile service structure.

In July 1962, NASA approved the Crawler Transporter concept, and in March 1963, a contract was awarded to Marion Power and Shovel Co. in Marion, Ohio, for the construction of two transporters.

Crawler Transporter

A credit to the individuals who designed the KSC Crawler Transporters is the fact they did not embark on exotic schemes that might have taken years to develop and would have cost many times more. Instead, they used existing and proven concepts that were modified and ingeniously applied to the Apollo program requirements.

Construction of the transporters as separate and independent of the mobile launch platform structures proved both prudent and visionary in light of future requirements of the transporters. Although modifications were necessary to support Space Shuttle operations, the transporters have truly become the workhorses of the Complex 39 area. They continue to function well in the 21st century using the basic design initiated in 1962.

Crawler Transporter Tread Belt Shoes

Each Crawler Transporter (CT) travels on eight tracked tread belts, each containing 57 tread belt "shoes." Each shoe is 7.5 feet long, 1.5 feet wide and weighs approximately 2,100 pounds. Over 1,000 shoes (456 per CT plus spares) were provided by Marion Power Shovel Co. when the CTs were initially built in 1965.

In the early 1980s, this original shoe quantity was supplemented with 228 new shoes per crawler from Bay City, Mich., and Kobe, Japan, foundries. These additional shoes permitted the implementation of a shoe

Crawler-Transporters are parked near the Vehicle Assembly Building.

refurbishment program in the late 1980s, as each CT approached 1,000 miles. To date, more than 500 shoes have been refurbished and placed into operation. The CTs performed well for nearly 40 years supported by the shoe refurbishment program, which was designed to extend shoe life indefinitely.

However, in September 2003, a crack was found on an original Marion shoe. In the following months, additional inspections revealed that this crack was not an isolated occurrence, prompting the acceleration of new shoe procurement activities. Subsequent NASA/USA analysis revealed that the existing shoes were experiencing premature fatigue failures due to internal manufacturing flaws that dramatically reduced the service life of the shoes.

In December 2003, the development of more restrictive design specifications was initiated specifically to preclude the manufacturing flaws found in the existing shoes. ME Global was the only domestic supplier that proposed to manufacture all of the required shoes within both the quality and schedule requirements. In mid-May 2004, ME Global was contracted to produce all of the required replacement shoes pending successful qualification of their production process.

In time to support Return to Flight, the first of 53 shipments (19 shoes) arrived at KSC in early September 2004, with others following shortly after.

The CT at work

One of the two CTs transports the assembled Space Shuttle, sitting atop the Mobile Launcher Platform, from the VAB to Launch Pads 39A and 39B.

Normally, the CT lifts the Mobile Launcher Platform from its parking site pedestals at the refurbish-

New crawler shoes waiting to be installed.

ment area, carries it into the VAB, and lowers it onto the pedestals in the high bay.

When the orbiter has been mated to the external tank and Solid Rocket Boosters, thus becoming the Space Shuttle, the CT lifts the Mobile Launcher with the Space Shuttle, and carries it to the launch pad using a laser guidance system and a leveling system on the crawler.

Once at the pad, the CT lowers the Mobile Launcher onto the pad pedestals. The CT then moves to a park site away from the pad to avoid possible damage from launch. After the Space Shuttle is launched, the CT lifts the Mobile Launcher from the pad and returns it to the parking location for refurbishment.

The Crawler Transporter consists of these systems and subsystems:

AC Power	DC Power
Auxiliary Power	Hydraulic
Pneumatic	Steering
Engine Monitor	DC Propel
Lubrication	Instrumentation

Integrated Monitor and Control
Jacking, Equalizing and Leveling
Fire Detection, Alarm and Protection

Crawler Transporter Facts

Height

Minimum (Cylinders retracted) ....20 feet
Maximum (Cylinders extended) ....26 feet

Size

Overall ....131 feet long /113 feet wide

The four contact points that the crawler makes to the MLP are arranged in a 90-foot square (same as the base line on a major league baseball field).

Cylinders

Jacking Hydraulic ....20-inch diameter (16 ea)
Steering Hydraulic ....14.5-inch diameter (16 ea)
Guide Tube (4 ea) ....40-inch diameter

Weight

Overall ....5.5 million pounds
Chassis ....2.2 million pounds (lifted by hydraulic system)

Speed

Loaded ....1 mph
Unloaded ....2 mph

Loads

MLP and Space Shuttle.........12 million pounds
MLP.....................................8.8 million pounds

Additional Facts

Trucks

Traction Motors (16 ea/4 per truck)...375 hp ea
Belts......................................8 ea (2 per truck)

Hydraulic System

Overall Capacity.............................3700-gallon
Steering ....4 pumps, 35.5 GPM @ 1200 RPM, per pump
Pressure........................0-5,200 PSI maximum
Jacking, Equalizing, Leveling (JEL).....8 pumps

Electrical System

<u>DC Power System</u> For 16 traction motors .... 375 hp
Diesel Engines ....Alco, 16 cylinders 2 @ 2,750 hp each
Generators (DC) ....4 @1,000 Kw each

<u>AC Power System</u> Runs all onboard systems
Diesel Engines ......White-Superior, 8 cylinders, 2 @ 1,065 hp each, for A/C power
Generators ....2 @ 750 kw each
Diesel Fuel Capacity .... 5,000 gallons
Fuel Consumption .... 42 feet per gallon (approximately 125.7 gallons per mile)
Drive System Gear Ratio..........................168:1

Upgrades

In 2003, the Crawler Transporters received several upgrades. The primary driver for the modifications was the upgrade of the Motor Control Center (MCC), which houses the switchgear and associated hardware necessary to electrically control all of its major systems onboard.

Installation of a new ventilation system for the engine and pump rooms, along with new diesel engine radiators, were integrated with the MCC upgrade. The new ventilation system allows for additional clean air to circulate, dropping temperatures by up to 25 degrees. Two additional subsystem modifications included the removal and replacement of the diesel engine exhaust systems and the two drivers' cabs.

The MCC cabinets and 60-Hz control panels were removed and replaced, along with old instrumentation and power cables. Refurbishment of 70 treadbelt shoes permitted the replacement of three complete treadbelts (171 shoes).

With the advent of the Space Shuttle Program, other transporters were needed to move the orbiters and payloads: Solid Rocket Motor, Orbiter and Payload Canister.

Solid Rocket Motor Transporters

The Solid Rocket Motor (SRM) is the largest solid propellant motor ever developed for space flight and the first built to be used on a manned craft. The huge motor is composed of a segmented motor case loaded with solid propellants, an ignition system, a movable nozzle and the necessary instrumentation and integration hardware. Each solid rocket motor contains more than 450,000 kg (1,000,000 lb.) of propellant.

The SRM segments are delivered to the Rotation, Processing and Surge Facility from Utah by railroad car, where they are unloaded onto pallets.

The SRM Transporter moves under the pallet, lifting both the pallet and the segment. The transporter then moves the pallets and segments to either the Surge Facilities for storage or to the VAB transfer aisle for segment stacking. Four fueled segments are required for each of the two Solid Rocket Boosters used on each Space Shuttle flight.

SRM Transporter Facts

Capacity .... 414,096 pounds
Dead Weight .... 204,800 pounds
Gross Weight .... 618,940 pounds

Number of Wheel Sets 12
Tires 48
Axle Load Capacity .... 70,480 pounds
Number Of Drive Axles................................... 6
Number Of Brake Axles.................................. 6
Tractive Power .... 70,925 pounds

Max. Gradient Ability Laden, Approx. 6%
Max. Crawl Speed, Unladen, Approx. 6.4 mph

Engine .... Cummins Diesel, Type NTA-855 C 400 water cooled

Height Of Lowered Platform.............. 63 inches
Lifting Stroke .... 27-9/16 inches
Axle Load Compensation...+/- 13-25/32 inches

Platform Size .... 612 x 239-3/8 inches
Outside Turning Radius, Approx. ....40 feet

The Solid Rocket Motor Transporter consists of these systems:

Drive	Lifting
Steering	Brake
Fire	Communications
Pneumatic	DC Power and Control
Diesel Engine and Cooling	

Orbiter Transporter System

The Orbiter Transporter System (OTS) is used to transport the Space Shuttle orbiters from the Orbiter Processing Facility to the VAB, prior to mating the orbiter with the external tank and Solid Rocket Boosters.

Since its arrival at KSC from Vandenberg Air Force Base, Calif., in 1989, the OTS has carried nearly every orbiter to the VAB for mating operations.

Orbiter Transporter Facts

Length ....106 feet 6 inches
Width ....20 feet at rear/8 feet in front/ 16 feet 8 inches in middle
Height ....5 feet 3 inches minimum to 7 feet 3 inches maximum

Engine ....335 hp, V12, air cooled
Wheels..76
Turning Radius ....66 feet

Weight Empty ....167,000 pounds
Weight Gross ....327,000 pounds

Speed Unloaded ....13 mph
Max. Speed Loaded ....5 mph

Atop its transporter, orbiter Endeavour rolls back onto the tow-way for transfer to the VAB.

A payload canister is on its way to the launch pad riding atop a payload canister transporter.

Payload Canister Transporter

Two payload canister transporters are used to move the payload canisters and their associated hardware throughout KSC. The original transporters were replaced in January 2000, manufactured by KAMAG Transporttechnik, GmbH, of Ulm, Germany.

Each transporter is a 12-bogie wheel, 24-tire, self-propelled vehicle designed to operate between and within Space Shuttle payload processing buildings, such as the Vertical Processing Facility, the OPF and the pads. The transporter can carry the payload canister either horizontally or vertically.

The transporter's wheels are independently steerable, permitting it to move forward, backward, sideways or diagonally and to turn on its own axis like a carousel. It is equipped with pneumatic actuated braking and hydrostatic leveling and drive systems. It is steered from a two-seat operator cab mounted at one end.

A transporter minus the canister weighs 136,600 pounds. It has a gross weight of 308,600 pounds when outfitted with the canister and payloads riding atop, with 527 gallons of diesel fuel and with the environmental control system, fluids and gas service, electrical power system, and instrumentation and communication system modules.

Because payload handling requires precise movements, the transporter has a creep mode that permits it to travel at 0.25-inch per second or 0.014 mph. When moving between buildings or sites, the transporter uses a 340-horsepower, turbo-charged diesel engine.

Indoors, drive power relies on a 45-kilowatt, 480 VAC 3-phase electric motor to avoid exhausting hydrocarbons inside the clean room environment.

Payload Canister Transporter Facts

Length ....65 feet
Width...23 feet
Flatbed Height ....Varies from 5 feet 3 inches
to 7 feet +/- 3
inches

Weight, Unloaded ....230,000 pounds
Weight, Gross ....258,320 pounds

Speed, Unloaded ....10 mph
Speed, Fully Loaded ....5 mph
Creep Mode ....0.014 mph
(or 0.25 of an inch per second)

At the launch pad, a payload canister carrying a Multi-Purpose Logistics Module is lifted up the Rotating Service Structure (left) to the Payload Changeout Room. Below, the Payload Canister Transporter maintains the clean environment via the umbilicals (red) still attached.

Sitting atop the Mobile Launcher Platform and Crawler Transporter, Space Shuttle Atlantis creeps toward the launch pad at about 1 mph for launch on mission STS-110.

This and other KSC fact sheets can be found on the Web in color at http://www-pao.ksc.nasa.gov/kscpao/nasafact/docs.htm

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